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Number II.

The working speed of ocean cables with the mirror system is as follows:

NUMBER OF WORDS PER MINUTE.

Weight of copper strands, lbs.	Knots, 1,000.	Knots, 1,500.	Knots, 2,000.	Knots, 2,500.
100	18·3	8·1	4·6	2·9
150	27·5	12·2	6·9	4·4
200	37·0	16·4	9·2	5·9
250	46·0	20·4	11·3	7·4
300	55·0	24·4	14·0	8·8
350	64·1	28·5	16·0	10·3
400	73·2	33·5	18·3	11·7

The apparatus employed in the transmission of communications through ocean cables is the invention of Professor Sir William Thomson. Ampère suggested, as early as the year 1820, the employment of a galvanometer for the purpose of telegraphing, and in 1833 Gauss and Weber used a reflecting galvanometer as an indicator upon a line about one mile in length, uniting the Observatory and the Physical Cabinet at Göttingen. Their alphabet was made up of combinations of right and left deflections. This apparatus, the first ever employed for practical telegraphy, has lately, in the hands of Professor Sir William Thomson, become the most sensitive of all telegraphic instruments. His reflecting galvanometer is the only instrument at present with which a cable 2,000 miles in length can be successfully worked by a battery of low tension. It consists of a needle formed of a piece of watch spring, three eighths of an inch in length. The needle is suspended by a thread of cocoon silk without torsion. The needle lies in the center of an exceedingly delicate galvanometer coil. A circular mirror of silvered glass is fixed to the needle, and reflects at right angles to it in the plane of its motion. It is so curved that, when the light of a lamp is thrown through a fine slit on it, the image of the slit is reflected on a scale about three feet off, placed a little above the front of the flame. Deflections to the extent of half an inch along any part of the scale are sufficient for one signal. In so delicate an instrument, the sluggish swing of the needle in finally settling into any position would destroy its usefulness. To rectify this, a strong magnet, about eight inches long and bent concave to the instrument, is made to slide up and down a rod placed in the line of the suspending thread above the instrument. This magnet can be easily shifted, as necessity may require. The oscillations of the needle due to itself are, by the aid of the strong magnet, made so sudden and short as only to broaden the spot of light.

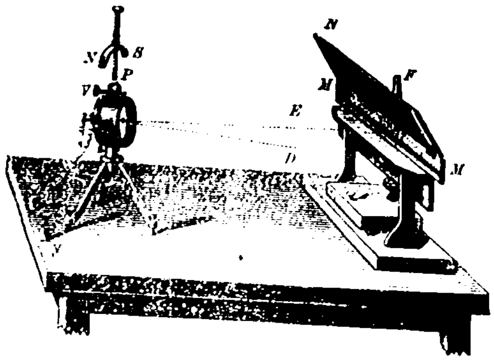

FIG. 6.

The above illustration (Fig. 6) shows the construction of the instrument. The galvanometer, P, contains the multiplication wire, divided into several layers and so arranged that it can be used for weak or strong currents, according to the requirements of the instrument. In the center of the coil the magnetic needle is suspended, to which is attached the tiny mirror, and close before it is to be found a small collective lens, whereof the focal point lies almost in the mirror, in order to produce a sharp figure of the prism on the scale.

The magnetic needle has a length of only $\frac{3}{8}$ of an inch, a breadth of $\frac{1}{16}$ of an inch, and a thickness of $\frac{1}{72}$ of an inch. The mirror connected with the needle has a thickness of only $\frac{1}{100}$ of an inch. The magnetic needle is made from a small piece of a very fine watch spring, and the little mirror, from one of the thinnest microscopic cover glasses. The magnetic needle and mirror used for signaling across the Atlantic weigh only $1\frac{1}{4}$ grains.

The entire box which encloses these parts is hermetically closed. The ends of the multiplicator wires are soldered inside the box to two screw posts, *x y*, wherewith the instrument is connected with the cable.

A curved steel magnet, N S, is fixed to a brass bar, P, in such a way that, by turning the micrometer screw, V, any required removal, upwards or downwards or to the right or left, can be given to it; and by this means the magnetic needle, when in a state of rest, is kept in such a position that the picture of the slit, D, which is reflected from the middle of the mirror, and likewise returns through the lens, appears upon the zero mark of the scale, M M.

Opposite the galvanometer, the scale, M M, and the lamp, F, are to be seen. The light from the lamp penetrates through the slit, D, in an oblique direction to the looking glass, and is thrown back from it to the scale somewhat upwards, in the direction, F, where the picture of the slit is to be seen as a fine light line. The screen, N, can be turned up and serves to keep the lamp light from the scale. The instrument is necessarily used in a darkened room.

The transmitting key is shown in Fig. 7. It consists of two separate levers, L and E, moving on axes at the upper end in the figure. They are kept, by springs, pressing against the cross plate, C, which is in connection with one of the poles of the battery. L is connected with the cable and E to the earth. When either key is pressed down, it falls on the plate, Z, in connection with the other pole of the battery. In the normal position of the key, the cable is connected, through L, C, and E, to earth, and Z is insulated; and it is easy to see how a positive or negative current is put to line according as L or E is depressed.

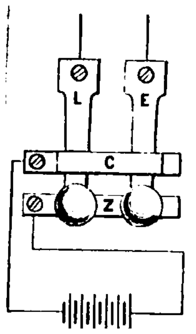

FIG. 7.

The alphabet is made by opposite movements produced by one or other of the keys. The signals need not be made from zero as a starting point. The eye can easily distinguish, at any point in the scale to which the spot of light may be deflected, the beginning and the end of a signal, and when its motion is caused by the proper action of the needle or by currents. It is thus that the mirror galvanometer is adapted to cable signaling, not only by its extreme delicacy, but also by its quickness. The deflections of the spot of light have been aptly compared to a handwriting, no one letter of which is distinctly formed, but yet is quite intelligible to the practised eye. Signals in this way follow each other with wonderful rapidity. A low speed of from twelve to sixteen words per minute is adopted for public messages; but when the operators communicate with each other, a speed of twenty-four words per minute is sometimes attained.

Condensers are used at both ends of the Atlantic cables, by means of which the speed is very considerably increased. The term condenser has long been used among electricians to denote an arrangement, in a moderate compass, equivalent to a Leyden jar of enormous capacity. It is composed of alternate layers of mica or parafined paper and tinfoil. One coating of this Leyden jar is put in direct communication with the conductor of the cable, and the other is joined to the sending key. At the other end of the cable one coating of the condenser is connected with the cable and the other coating with the receiving instrument. The condensers are each equal to about 70 miles of the cable. The condenser serves two purposes: it lessens the delay caused by induction, and prevents the disturbance of the signals by earth currents. The cable and condenser being insulated, there is no voltaic circuit, and no way whereby earth currents can enter and leave the line.

The question is often asked: "What is the velocity of electricity?" or "how long does electricity take to go across the Atlantic Ocean?" Electricity cannot properly be said to have a velocity, but differs with the circumstances under which it travels. For about two tenths of a second after contact is made with the conductor of an Atlantic cable, no effect is perceptible on the opposite side of the ocean, even by the most delicate instrument. After four tenths of a second, the received current is about 7 per cent of the maximum permanent current which the battery could produce in the circuit. One second after the first contact, the current will reach about half its final strength, and after about three seconds its full strength. The current does not arrive all at once, like a bullet, but grows gradually from a minimum to a maximum.

The Direct United States Cable, which is now being laid between Ireland and Nova Scotia, and thence to Rye Beach, New Hampshire, is 3,060 nautical miles in length. The core is composed of a thick copper wire encircled by eleven very fine copper wires, weighing 480 pounds per mile, and is served with four coatings of gutta percha, measuring about three eighths of an inch in diameter. After the serving with gutta percha comes a serving with manilla hemp, which brings the core up to a thickness of three fourths of an inch; and then follows the sheathing with iron wire, which forms the outer covering of all. Ten iron wires are employed for this purpose: but before being applied to the cable, they are each wound with five strings of manilla hemp, so as to impart greater strength, and protect them from the action of water. The hemp covered wires are served with a species of black compound resembling tar or pitch; and after being twisted around the core, they are again served in this manner, and finally whipped with Italian hemp, which, however, can scarcely be said to do more than hold the strands in their places until the whole becomes hard and dry. This is the deep sea portion of the cable. The shore ends are of varying sizes, graduating from about $2\frac{1}{2}$ inches down to $\frac{3}{4}$ of an inch.

The Direct United States Company expect to obtain a speed of about nine words per minute, or about one half that of the present Newfoundland and Ireland cables.

The French Atlantic Cable, laid in 1869 between Brest and St. Pierre, has 400 pounds of copper per mile, is 2,584 knots in length, and has a working speed of fifteen words per minute.

The contract price of the Direct United States Cable, laid down, is $6,055,000. The cost of the Anglo-American Cable —between Ireland and Newfoundland—laid down, was $1,500 per mile.

The Direct United States Cable has been laid from Ireland to within a distance of about 200 miles of Nova Scotia; but owing to unfavorable weather it had to be cut and buoyed. It will probably be recovered again as soon as favorable weather ensues, and its laying be successfully completed. When this is accomplished, there will be five working cables across the North Atlantic and one across the South Atlantic oceans.

Submarine telegraph cables now extend across the North and South Atlantic, Indian, and German Oceans; the Mediterranean, Red, North, Baltic, Chinese, Oriental, Japan, Java, and Caribbean Seas; the Gulfs of Biscay, Bengal, Mexico, and St. Lawrence, and the straits of Bass and Malacca: thus placing North and South America, the West Indies, Europe, India, Java, Australia, Tasmania, and Siberia in constant and instantaneous telegraphic communication, as well as affording communication with the most important ports in China and Japan.

The following is a list of the more important cables which are in working order at the present time:

Date.	From	Length in Miles.
1851.	Dover, England, to Calais, France	25
1852.	Holyhead, Wales, to Howth, Ireland	65
	Port Patrick, Scotland, to Donaghadee, Ireland	25
	Prince Edward Island to New Brunswick	12
1853.	Denmark, across the Belt	18
	Dover, England, to Ostend, Belgium	80½
	Port Patrick, Scotland, to Donaghadee, Ireland	25
1854.	Port Patrick, Scotland, to Whitehead, Ireland	27
	Sweden to Denmark	12
	Holyhead, Wales, to Howth, Ireland	65
1856.	Prince Edward Island to New Brunswick	1
	Crete or Candia to Syra, Greece	170
	St. Petersburgh to Cronstadt, Russia	10
	Across the Amazon	105
1857.	Ceylon to Hindostan	80
	Norway across the Fiords	49
1858.	England to Holland	140
1859.	Denmark to Heligoland	46
	Isle of Man to Whitehaven, England	86
	Sweden to Gottland	64
	Folkestone, England, to Boulogne, France	24
	Malta to Sicily	60
	Jersey to Pirou, France	21
1860.	Great Belt, Denmark (two cables)	14
	Cape St. Martin, Spain, to Iviza	76
	Iviza to Majorca	74
1861.	Corfu to Otranto, Italy	90
	Dieppe, France, to Newhaven, England	80
1862.	Wexford, Ireland, to Aberman, Wales	63
	Lowestoft, England, to Zandvoort, Holland	125
1864.	Fao, Persia, to Bushire, Persia	204
	Bushire, Persia, to Masandam, Persia	450
	Masandam, Persia, to Gwadar, Beloochistan	447
	Gwadar, Beloochistan, to Kurrachee, British India	346
	Otranto, Italy, to Avlona, Turkey	50
1865.	Trelleborg to Rugen, Germany	55
	South Foreland, England, to Cape Grisnez, France	25
1866.	Ireland to Newfoundland	1,896
	Lyall's Bay to White's Bay	41
	Crimea to Circassia	40
	Colonia to Buenos Ayres	30
	England to Hanover	224
	Cape Ray, Newfoundland, to Aspee Bay, Cape Breton	91
	Leghorn, Italy, to Corsica	65
	Persian Gulf	160
1867.	South Foreland, England, to La Panne, France	47
	Malta to Alexandria, Egypt	925
	Placentia, Newfoundland, to St. Pierre	118
	St. Pierre to Sydney, Cape Breton	126
	Arendal, Norway, to Hirtshals, Denmark	68
1868.	Italy to Sicily	5
	Havana to Key West, Florida	125
1869.	Peterhead, Scotland, to Egursand, Norway	250
	Grisselhamm, Sweden, to Nystadt, Russia	96
	Newbiggin to Sondervig	334
	Malta to Sicily	54
	Tasmania to Australia	176
	Scilly Isles to Land's End, England	27
	Ithaca to Cephalonia	7
	Bushire, Persia, to Jask, Beloochistan	505
	Brest, France, to St. Pierre	2,584
	St. Pierre to Duxbury, U. S.	749
	Moen to Bornholm, Sweden	80
	Bornholm, Sweden, to Libau	230
1870.	Scotland to Orkney Isles	37
	Salcombe, England, to Brignogan, France	101
	Beachy Head, England, to Cape Autifee, France	70
	Suez, Egypt, to Aden, Arabia	1,460
	Aden, Arabia, to Bombay, India	1,818
	Porthcurno, England, to Lisbon, Portugal	823
	Lisbon to Gibraltar	331
	Gibraltar to Malta	1,120
	Marseilles, France, to Bona, Africa	447
	Bona, Africa, to Malta	380
	Madras to Penang	1,408
	Penang to Singapore	400
	Singapore to Batavia	557
	Malta to Alexandria, Egypt	904
	Batabano, Cuba, to Santiago, Cuba	520
	Jersey to Guernsey, Channel Islands	16
	Guernsey to Alderney, " "	18
	Santa Maura to Ithaca	7
	Zante to Trepito	11
	Sunium to Thermia	25
	Patras, Greece, to Lepanto	2
	Dartmouth, England, to Guernsey	66
	Guernsey to Jersey	15

Date.	From	Length in miles.
	Porto Rico to St. Thomas	110
	Santiago, Cuba, to Jamaica	140
	Port Patrick, Scotland, to Donaghadee, Ireland	25
	Anjer, Java, to Telok Betong, Sumatra	55
	Banjoewangie, Java, to Port Darwin, Australia	1,082
	St. Thomas to St. Kitts	133
	St. Kitts to Antigua	90
1871.	Javea to Iviza, Balearic Islands	53
	Majorca to Minorca	35
	Villa Real to Gibraltar	155
	Marseilles, France, to Algiers, Africa	447
	Singapore to Saigon, Cochin China	630
	Key West to Punta Rassa	120
	Saigon to Hong Kong	975
	Hong Kong to Shanghai	1,100
	Shanghai, China, to Nagasaki, Japan, thence to Wladiwostock, Siberia	1,200
	Rhodes to Marmarice	22
	Latakia to Cyprus	86
	Samos to Scala Nuova	11
	Myteleno to Aivali	13
	Khania to Retimo	32
	Rhetimo to Candia	41
	Candia to Rhodes	201
	Chios to Chesmeh	6
	Zante to Corfu	150
	Zante to Cephalonia	18
	Lowestoft, England, to Greitsell, Germany	223
	Antigua to Demarara, connecting the West India Windward Islands	1,023
	Porto Rico to Jamaica	582
1872.	Lizard, England, to Bilbao, Spain	460
	British Columbia to Vancouver Island	18
1873.	Falmouth England, to Lisbon, Portugal	1,150
	Caithness to Orkney	8
	Valencia to Newfoundland	1,900
	Key West to Havana	100
	Placentia, Newfoundland, to Sydney, Cape Breton	300
	Heligoland to Cuxhaven, Germany	40
	England to Denmark	450
	France to Denmark	550
	Denmark to Sweden	10
	Pernambuco, Brazil, to Para, Brazil	1,382
	Alexandria, Egypt, to Candia or Crete	390
	Candia to Zante	240
	Zante to Otranto, Italy	190
	Alexandria, Egypt, to Brindisi, Italy	930
1874.	Lisbon, Portugal, to Madeira, Madeira Islands	633
	Madeira to St. Vincent, Cape de Verde Islands	1,300
	St. Vincent to Pernambuco, Brazil	1,953
	Jamaica to Colon, South America	660
	Pernambuco, Brazil, to Bahia, Brazil	450
	Bahia, Brazil, to Rio Janeiro	1,240
	Italy to Sicily	7
	Jamaica to Porto Rico	582
	Rio Janeiro to Rio Grande do Sul	840
	Rye Beach, U. S., to Tarr Bay, Nova Scotia	550
	Barcelona, Spain, to Marseilles, France	200
	Shetland to Orkney	60
	Valencia to Newfoundland	1,900

The following is a list of the principal submarine telegraph companies, with the amount of their capital:

Anglo-American Telegraph Company: Ireland to Newfoundland; Newfoundland to Cape Breton; Brest to St. Pierre; St. Pierre to Duxbury, U. S. (five cables)—$35,000,000.

Brazilian Submarine Telegraph Company: Portugal to Brazil—$6,500,000.

Cuba Submarine Telegraph Company: Santiago to Havana —$800,000.

Direct Spanish Submarine Telegraph Company: England to Bilbao, Spain—$650,000.

Direct United States Submarine Telegraph Company: Ireland to Nova Scotia; Nova Scotia to the United States—$6,500,000.

Eastern Submarine Telegraph Company: England to Bombay *via* Mediterranean and Red Sea—$15,000,000.

Eastern Extension, Australian and China Submarine Telegraph Company: Madras to China and Japan; Java to Australia—$8,315,500.

Great Northern of Copenhagen Telegraph Company: England to Denmark, Norway, Sweden, and Russia—$2,000,000.

Great Northern China and Japan Extension: Siberia to Hong Kong and Japan—$3,000,000.

International Ocean Telegraph Company: Florida to Havana—$1,500,000.

Mediterranean Extension Telegraph Company: Sicily to Malta and Corfu—$760,000.

Montevidean and Brazilian Telegraph Company: Montevideo to Brazilian Frontier—$675,000.

Platino-Brazilian Telegraph Company Rio Janeiro to Uruguay—$2,000,000.

Submarine Telegraph Company: England to France, to Belgium, and to Holland—$2,093,200.

Western and Brazilian Telegraph Company: Coast of Brazil—$6,750,000.

West India and Panama Telegraph Company: Cuba to West India Islands and South America—$9,500,000.